REINHOLD ENVIRONMENTAL Ltd.

2013 NOx-Combustion Round Table & Expo Presentations

February 18 & 19, 2013, in Salt Lake City, UT / Hosted by PacifiCorp

MERCURY OXIDATION ACROSS THE AIR HEATER

ABS REMOVAL CO-BENEFIT

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REVIEW:

HgS Cinnabar Ore

$Hg^0 \approx 60\%$

Hg^{2+} $(HgCl_2) \approx 40\%$

Hg_p

REVIEW:

- Lower SO_3 Enhances Hg Capture
- Lower SO_3 Can Hurt ESP Performance
- Lower Temperature Enhances Hg Capture
- AH SO_3 Removal Increases At Lower Temp
- Ammonia Can Revert Hg^{2+} Back To Hg^0
- Ammonia Plus SO_3 Can Produce ABS

Hg COMBUSTION CHEMISTRY

- THERE IS A LOT WE DO NOT YET KNOW
- SCIENCE CONCERNING THE COMBUSTION CHEMISTRY OF MERCURY IS RELATIVELY NEW
- INITIAL ASSUMPTION: ADDITIVES ARE THE BEST WAY TO OXIDIZE Hg

BROMINE PAC PROBLEM?

RAPID CORROSION OF AIR HEATER ELEMENT

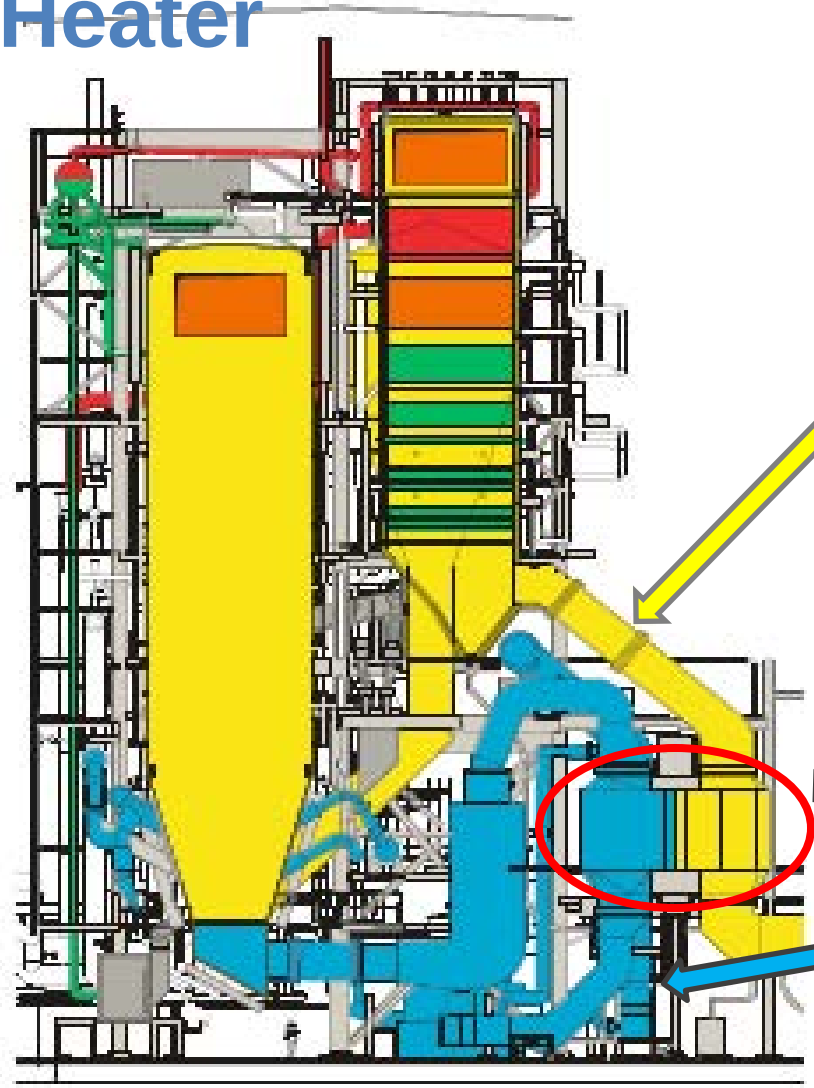
AH DETERIORATION

ACID RESISTANT COATINGS

PICK YOUR CORROSIVE

Downstream Corrosion

Air And Gas Flow From Air Heater



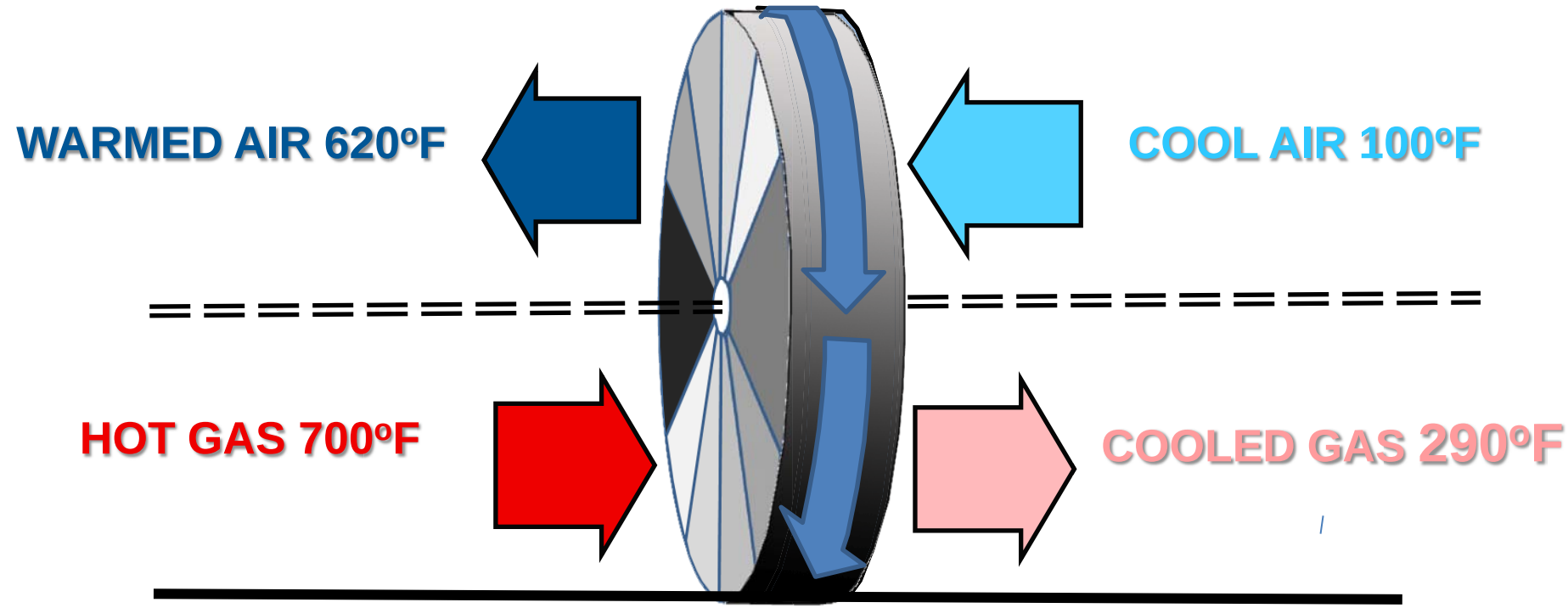
HOT FLUE GAS TO AIR HEATER

AIR HEATER

WARMED AIR TO BOILER

Function of an Air Heater

- Extracts Waste Heat From Exhaust Gases
- Recycles That Heat to the Incoming Air



Benefits of an Air Heater

- Accounts For ~10% - 15% Of a Unit's Thermal Efficiency

- Reduces Fuel Cost By $15,000,000 Per Year on a 500 MW Unit

Gas Outlet Temperature

- **ESTABLISHED STANDARD :**
  - **A 10°F Increase In Gas Outlet Temperature Decreases Boiler Efficiency By 0.25%**
  - **10°F Increases Fuel Cost By $ 750,000⁺/Yr**

Gas Outlet Temperature

GOAL:

Operate At Lowest Practical Gas Outlet Temperature

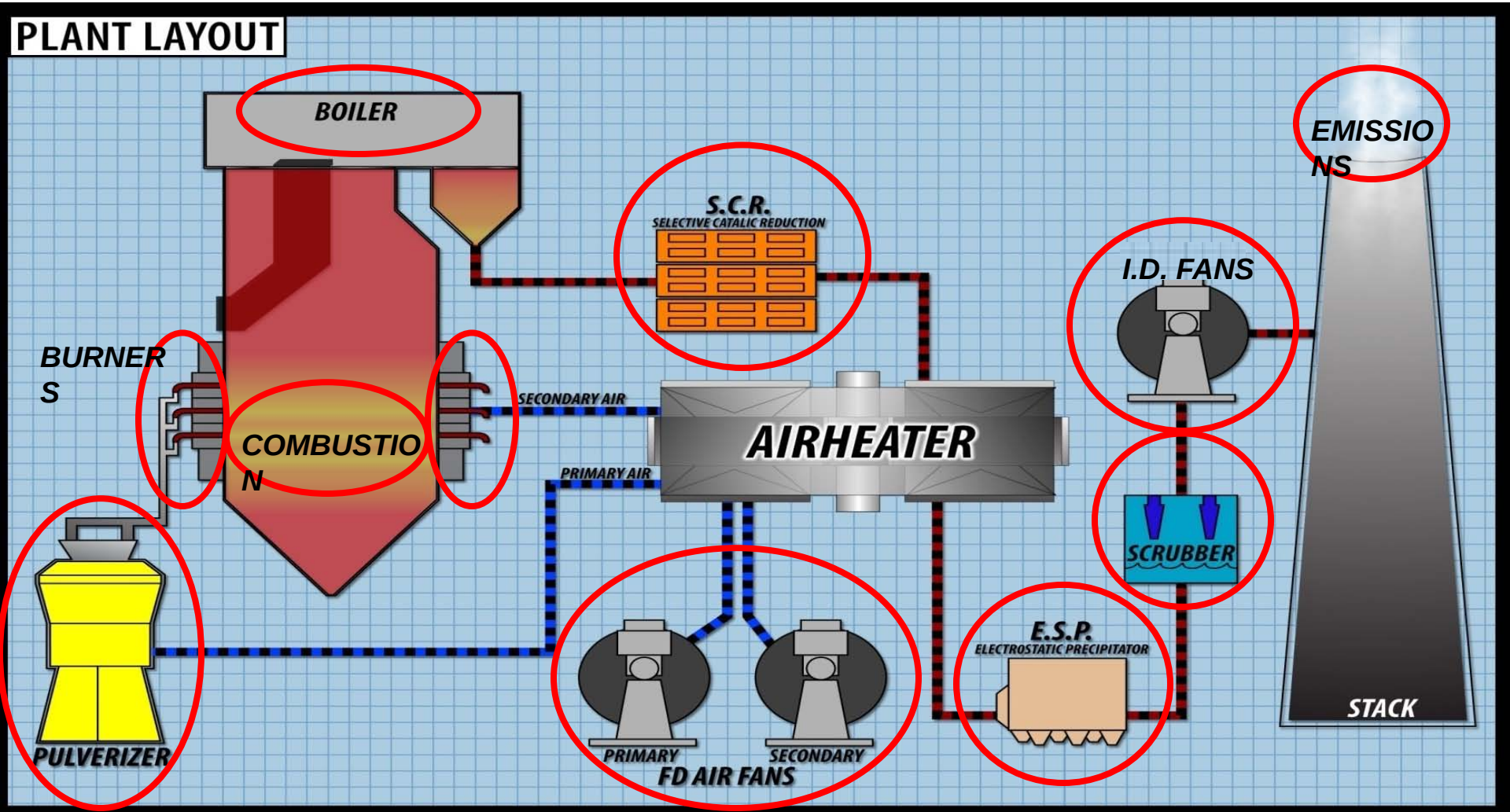
OBSTACLES:

Condensables

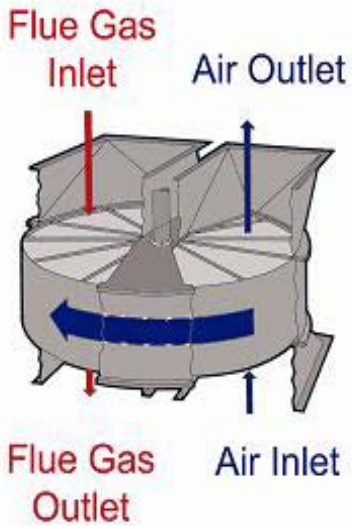
Effects of Gas Temperature on Equipment

The SCR Impacts the Air Heater

The Air Heater Impacts Combustion and APC Equipment



Combustion Airflow Distribution & Control



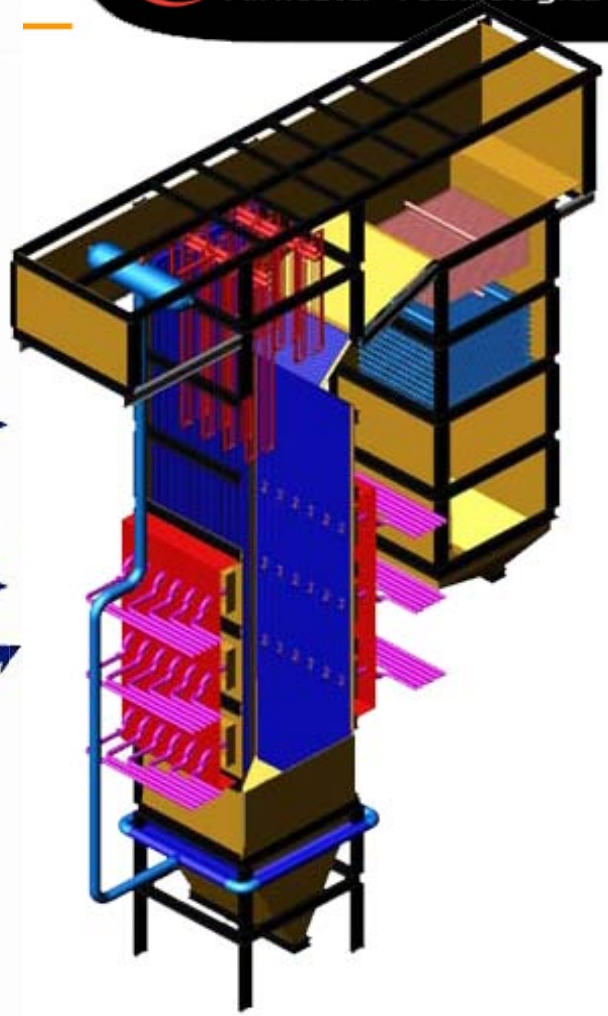
Over-Fire Air
(15 - 20%)

Secondary Air
(55%-65%)

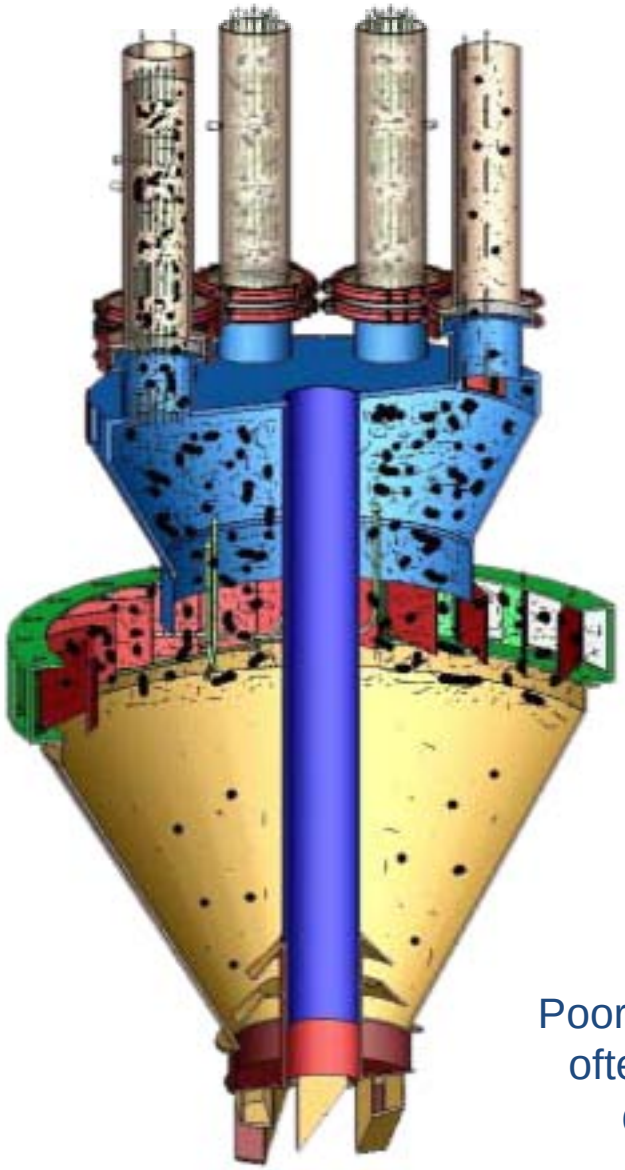
Fuel

Primary Airflow

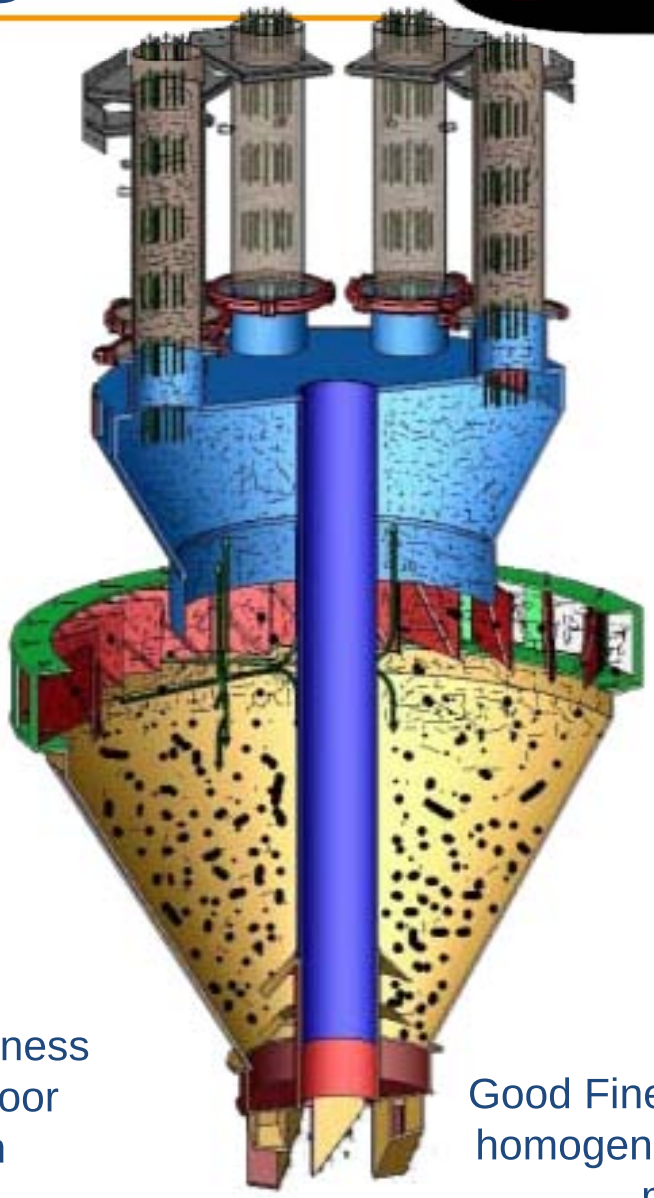
(15%-20%)



Coal Fineness

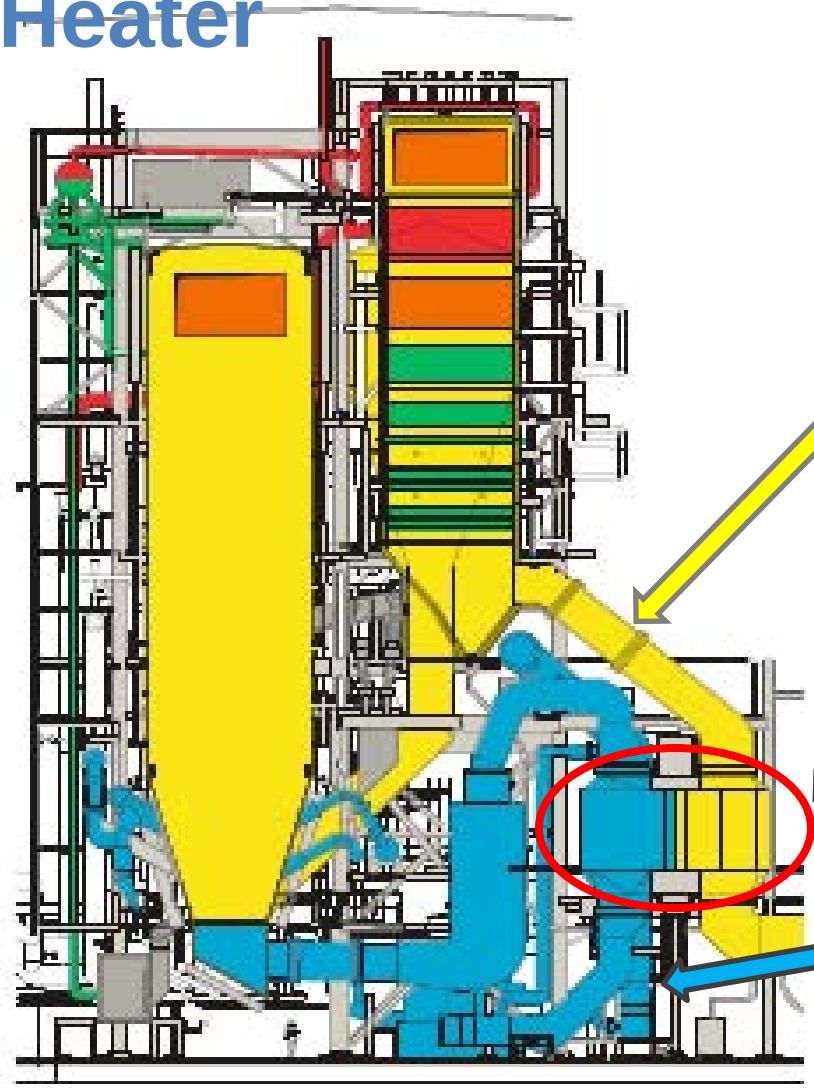


Poor Coal Fineness often yields poor distribution



Good Fineness Creates a homogenous & balanced mixture

Air And Gas Flow From Air Heater



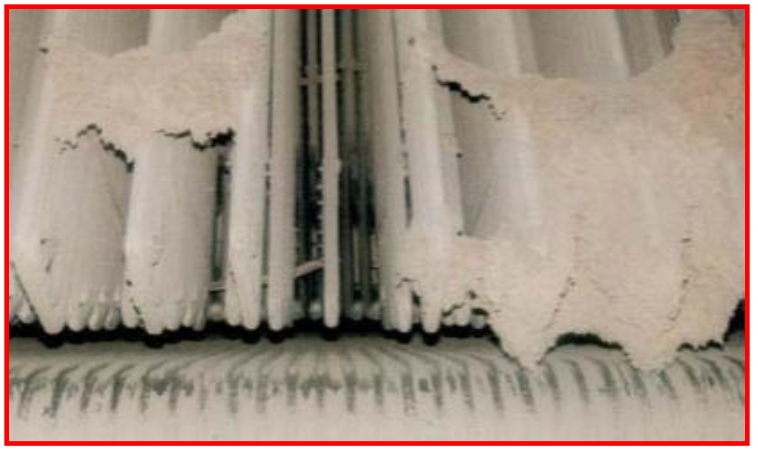
HOT FLUE GAS TO AIR HEATER

AIR HEATER

WARMED AIR TO BOILER

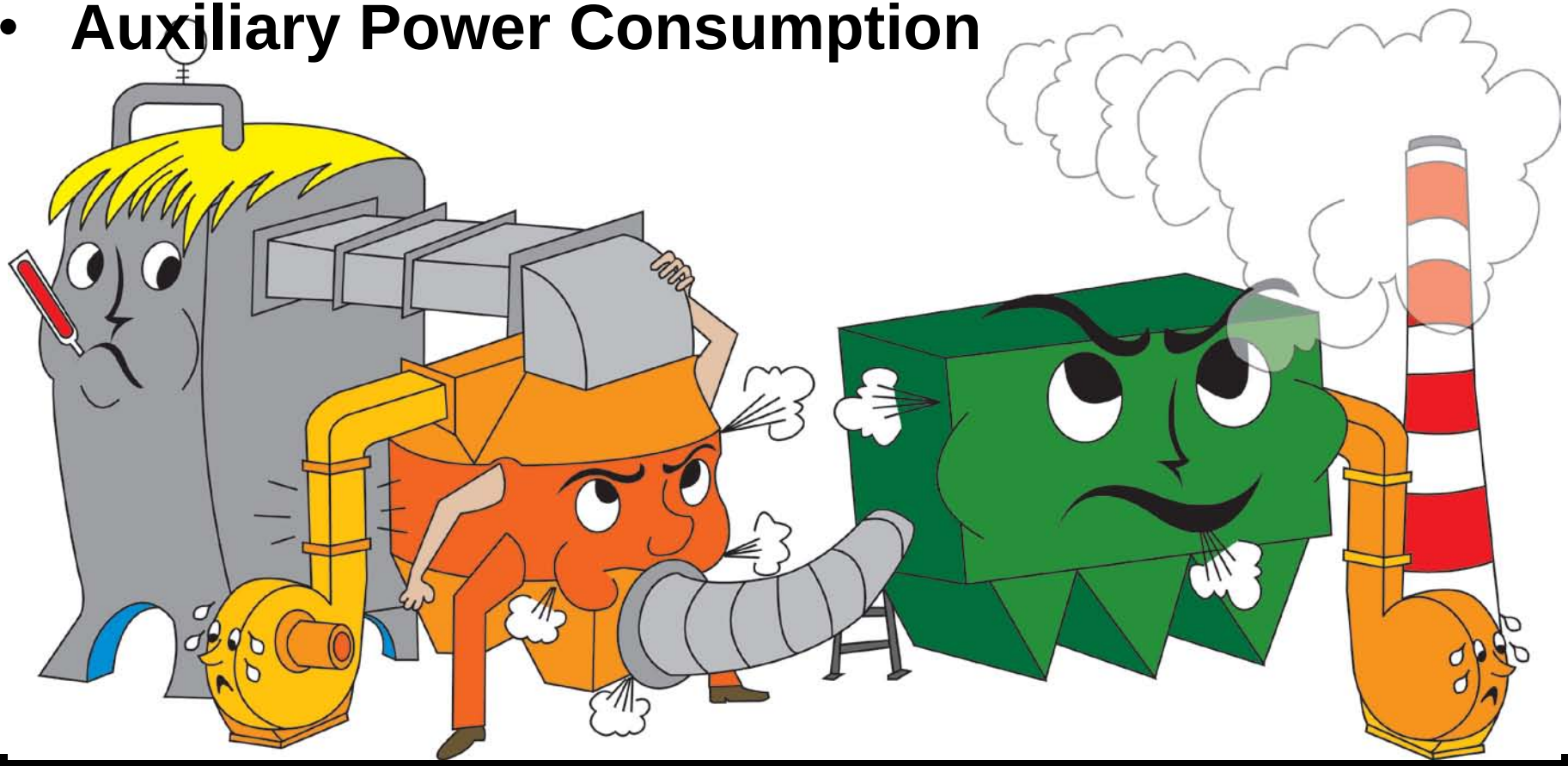
Catalyst Fouling

1. Low Primary Air Temp
2. Open Classifiers or ↑ Flow
3. Increase Coal Particle Size
4. Fireball Moves Upward
5. Increased FEGT
6. Popcorn Ash is Formed
7. Catalyst Fouls
8. NH3 Slip Increases
9. AH Fouls with ABS
10. Go to Step 1 - Repeat



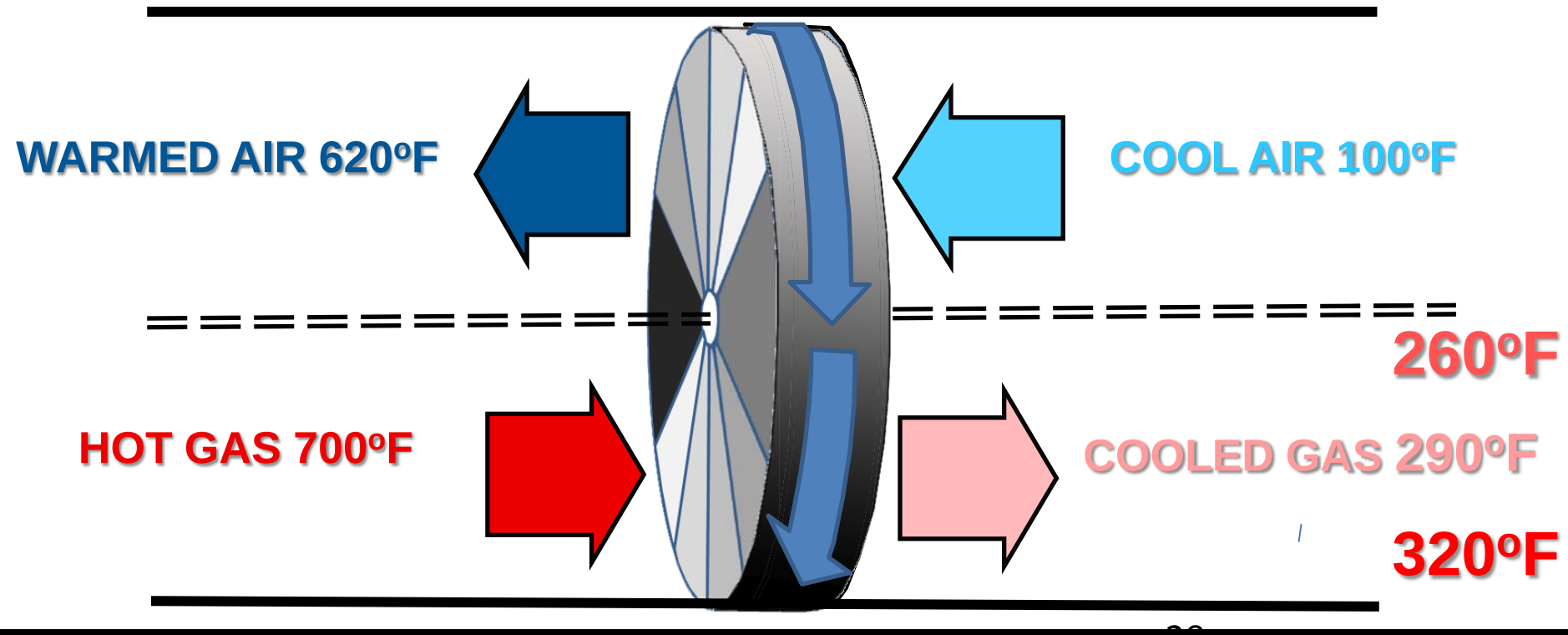
Inter-Relationships

- Combustion Performance
- APH performance
- Environmental Control Equipment
- Auxiliary Power Consumption

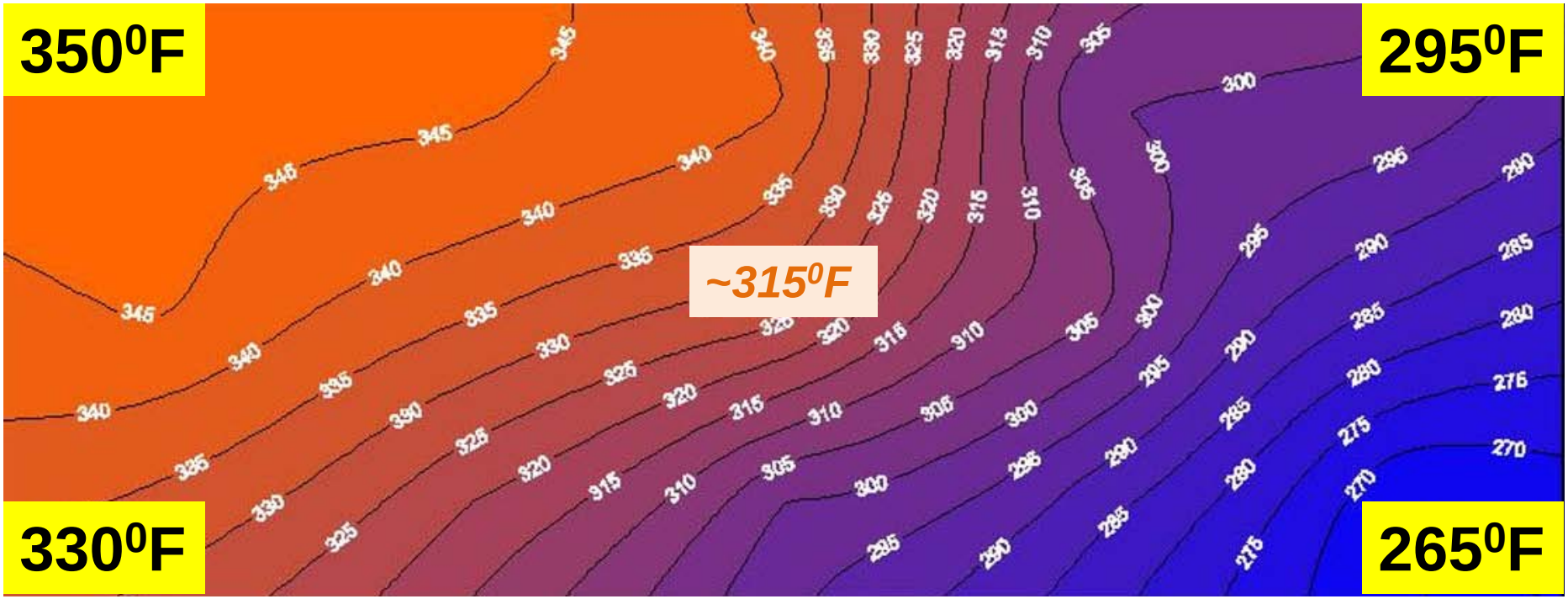


AIR HEATER TEMPERATURES

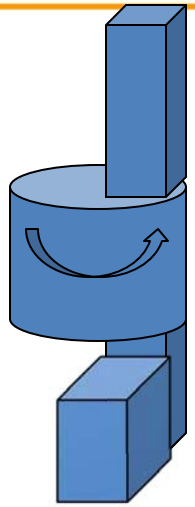
GAS OUTLET TEMPERATURE VARIES WITH ROTATION



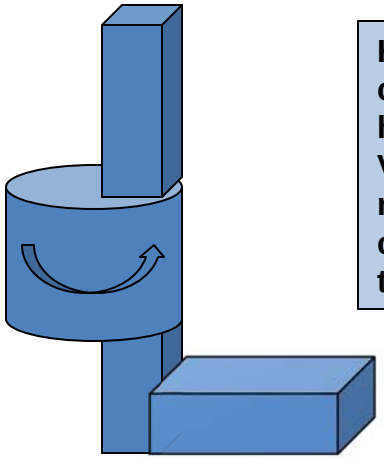
GAS TEMPERATURE PROFILE



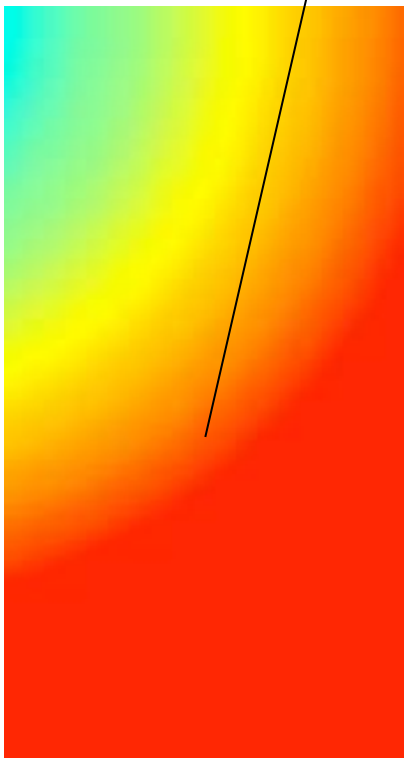
AH Outlet Duct Stratification

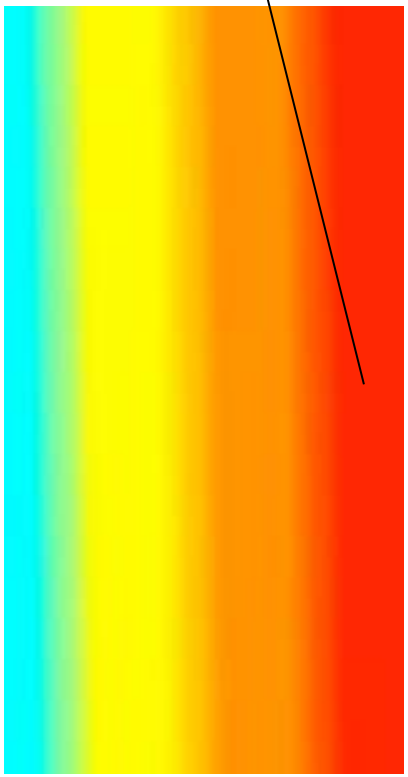


Low SO3 concentrations will have lower Vaporization Temp resulting in highest concentration in this band.



High SO3 concentrations will have higher Vaporization Temp resulting in highest concentration in this band.





Duct Orientation after the bend determines Temp stratification.

SO3 follows temp depending on SO3 concentration

5 ppm SO3 – Evap Temp = 275 DegF

10 ppm SO3 – Evap Temp = 289 DegF

Some stratification may also result from capture of Acid Vapor on Flyash particles and Aerosol Formation

SO_3 EXIT CONCENTRATION

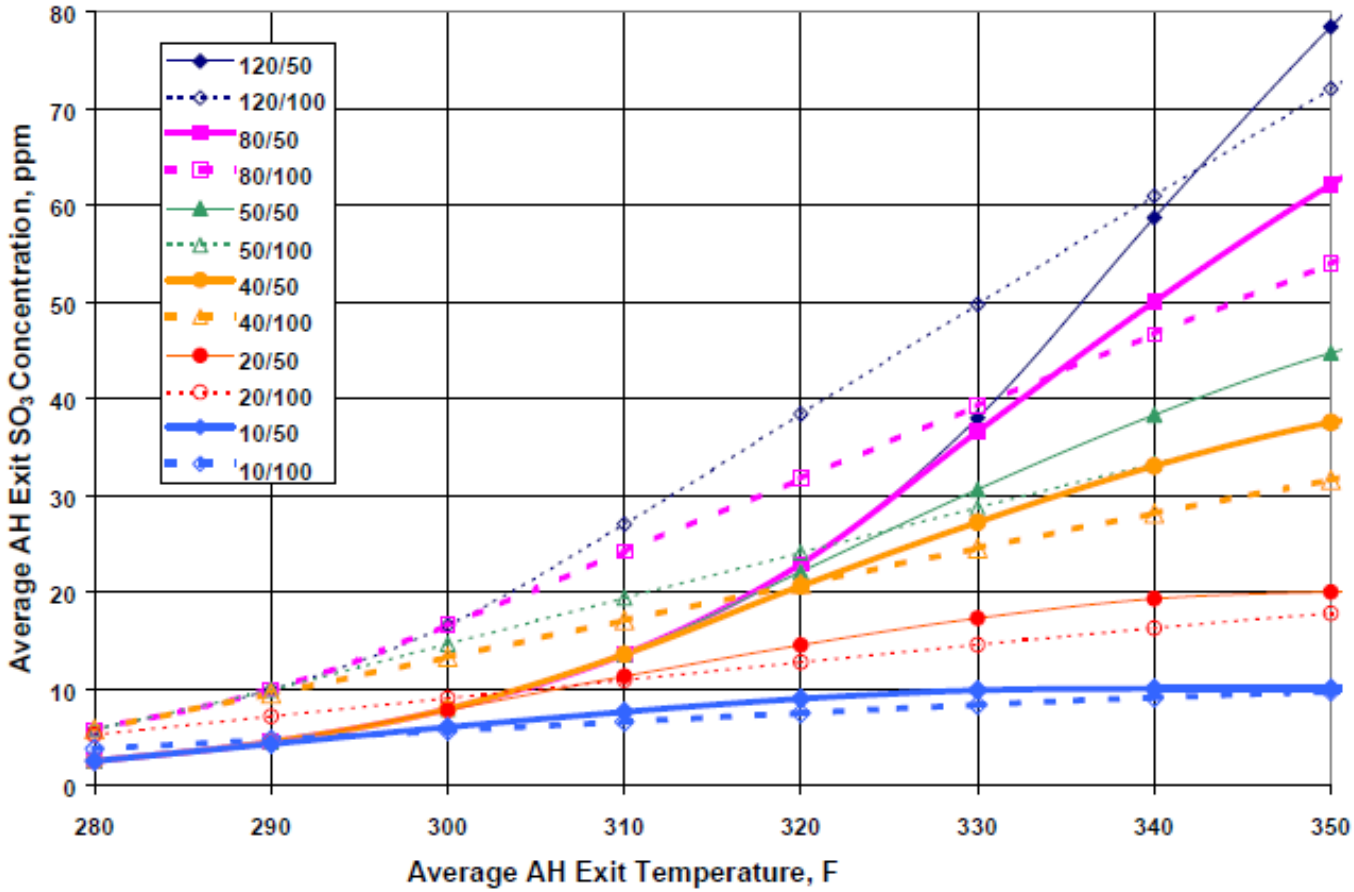
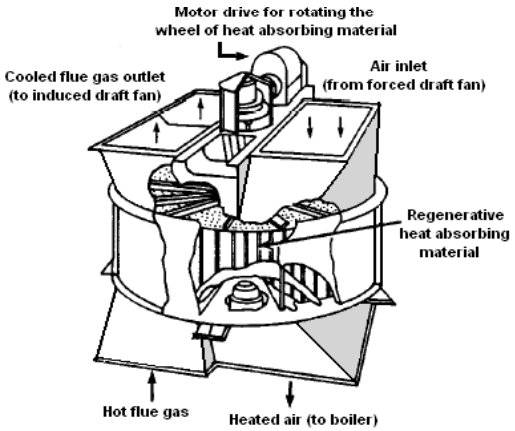


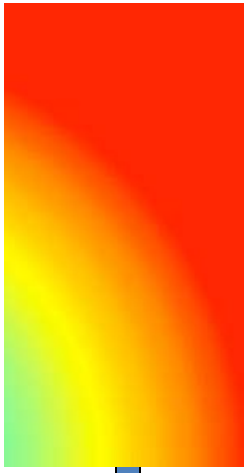
Figure 6.2. Estimated air preheater exit SO_3/H_2SO_4 concentration versus average air preheater exit temperature for a temperature offset of 35 °F. The first value of each pair in the legend is the preheater inlet SO_3/H_2SO_4 concentration in ppm and the second value of the pair is the spread in exit gas temperature between the cold side and the hot side of the preheater exit.

AH – Condense and Concentrate Device

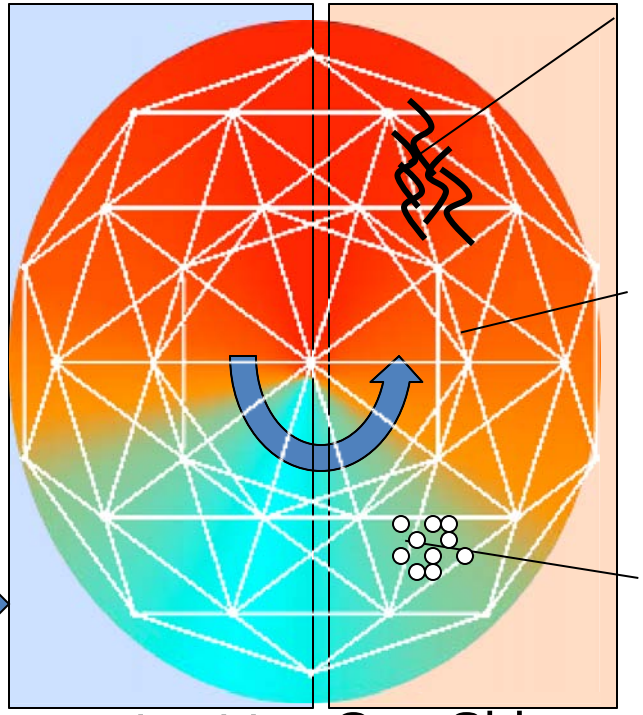


Rotating Lungstrom type Air heater (could be vertical or Horizontal Shaft)

Hot End



Cold End



Condensed Acid Vaporizes on the Hot metal

Metal not cold enough to condense and not hot enough to vaporize. Acid passes through.

Acid condenses on the cold metal

Concentrate

Condense

Air Side Gas Side

SO_3 Exiting the Air Heater

SO3 at AH Gas Inlet

Metal Temperature

Gas Temperature

Ash Quantity

Ash Alkalinity

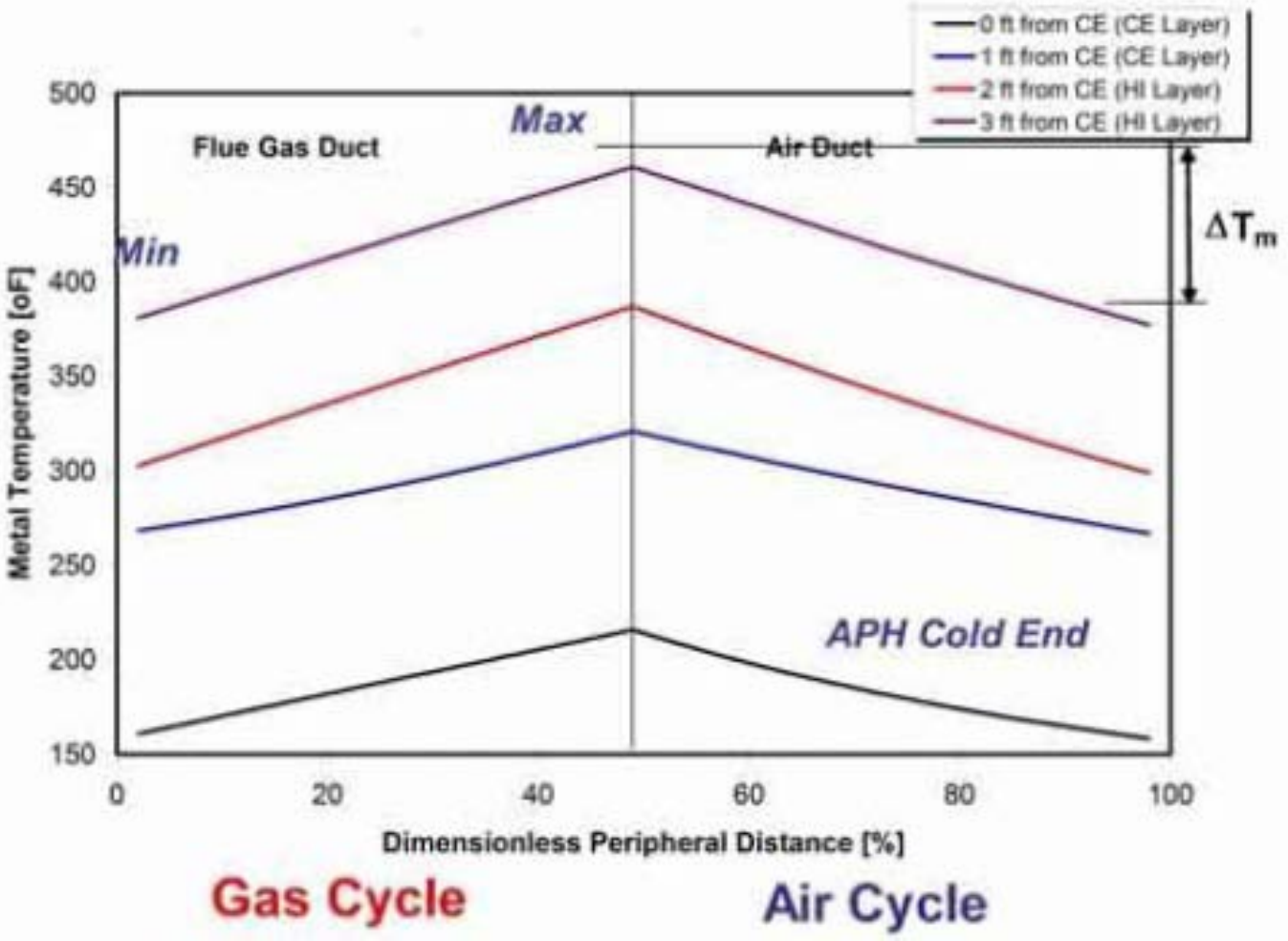
PM 2.5

THE AIR HEATER ALSO OXIDIZES Hg

NON-CATALYTIC Hg OXIDATION

- ON ANY AVAILABLE SURFACE:
- SURFACE TEMPERATURE 450°F ± 50°F
- $Hg + SO_x + O_2 \leftrightarrow HgSO_{4\,(s)}$ MERCURIC SULFATE
- $HgSO_{4\,(s)} + 2HCl_{(g)} \rightarrow HgCl_{2\,(s)}$ MERCURIC CHLORIDE
- $HgCl_{2\,(s)} \rightarrow HgCl_{2\,(g)}$ SUBLIMATION

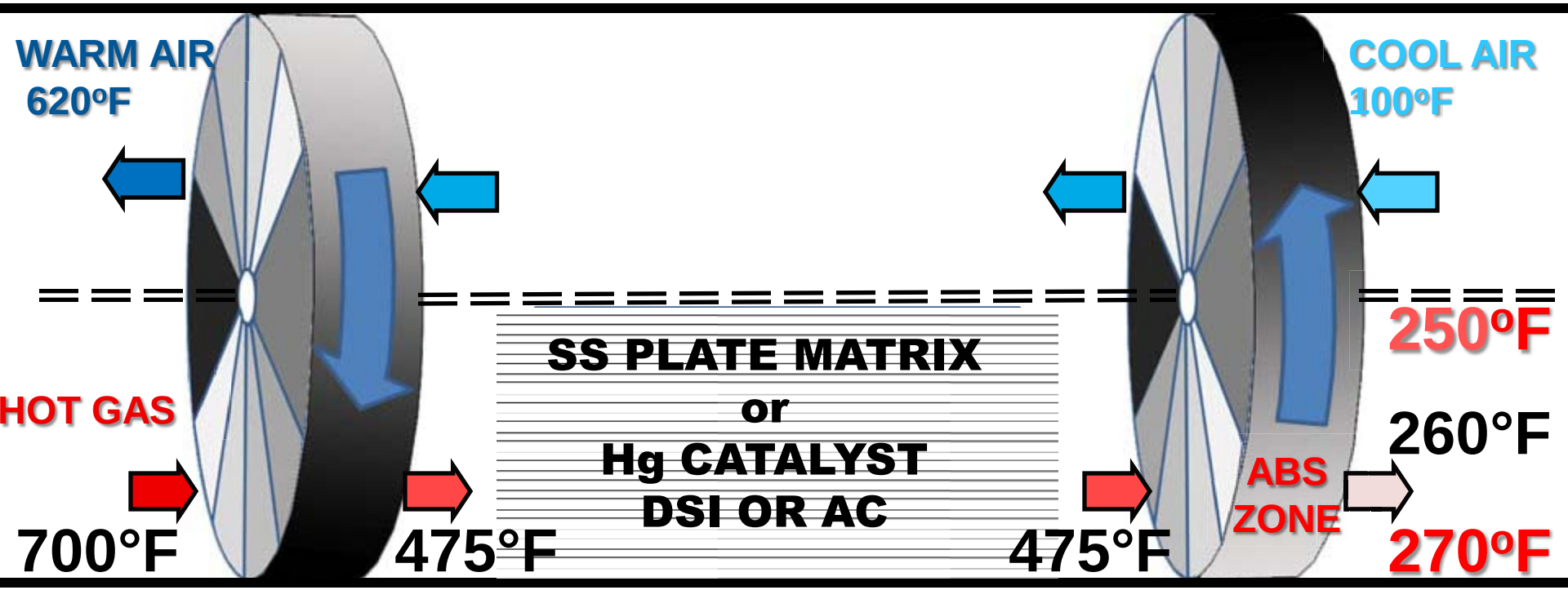
AH METAL TEMPERATURE



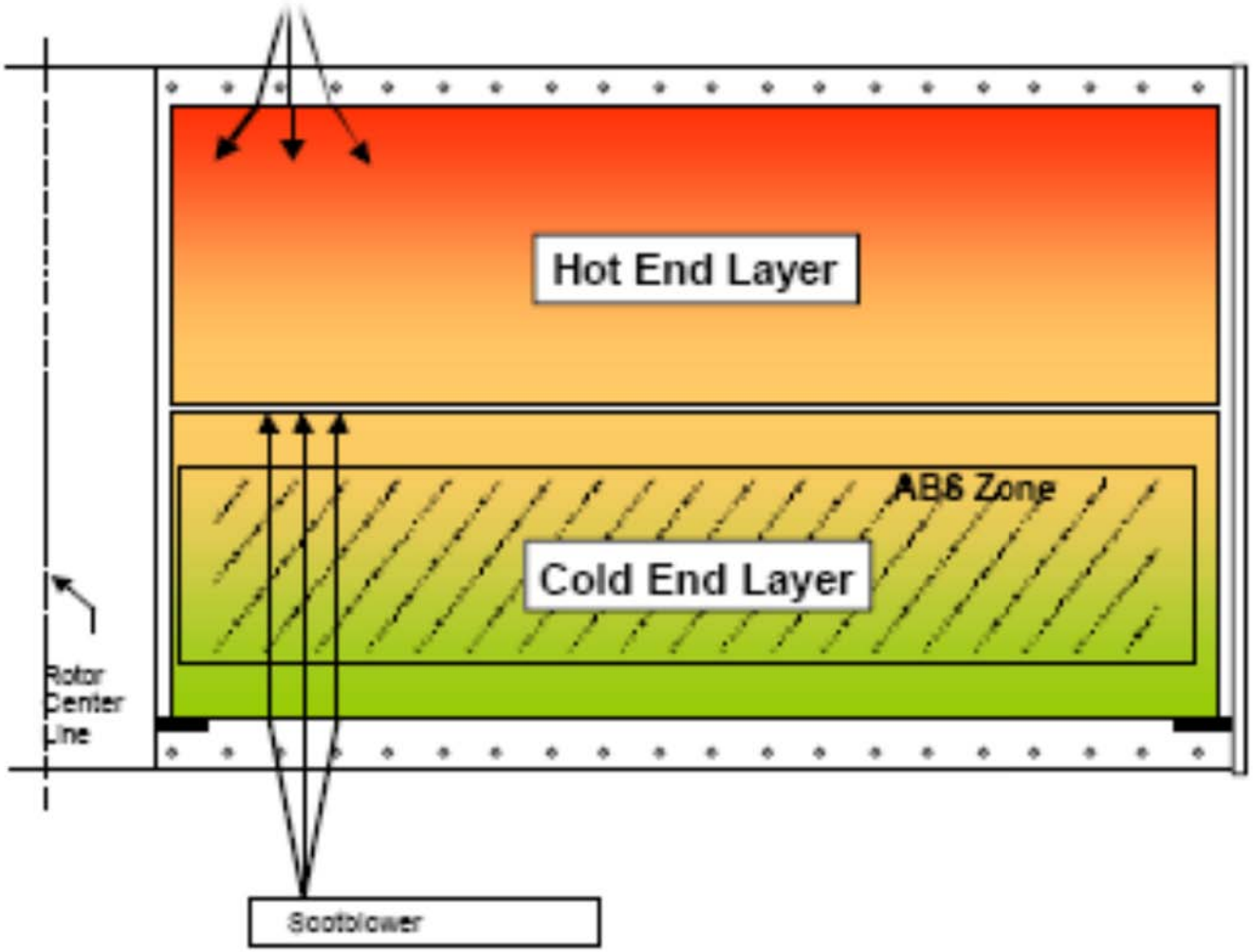
12” ACTIVE SURFACE

SIMULTANEOUSLY OPTIMIZING THE AIR HEATER AND THE APC EQUIPMENT

Hg OXIDATION AH ARRANGEMENT



ABS Zone - Two Layer

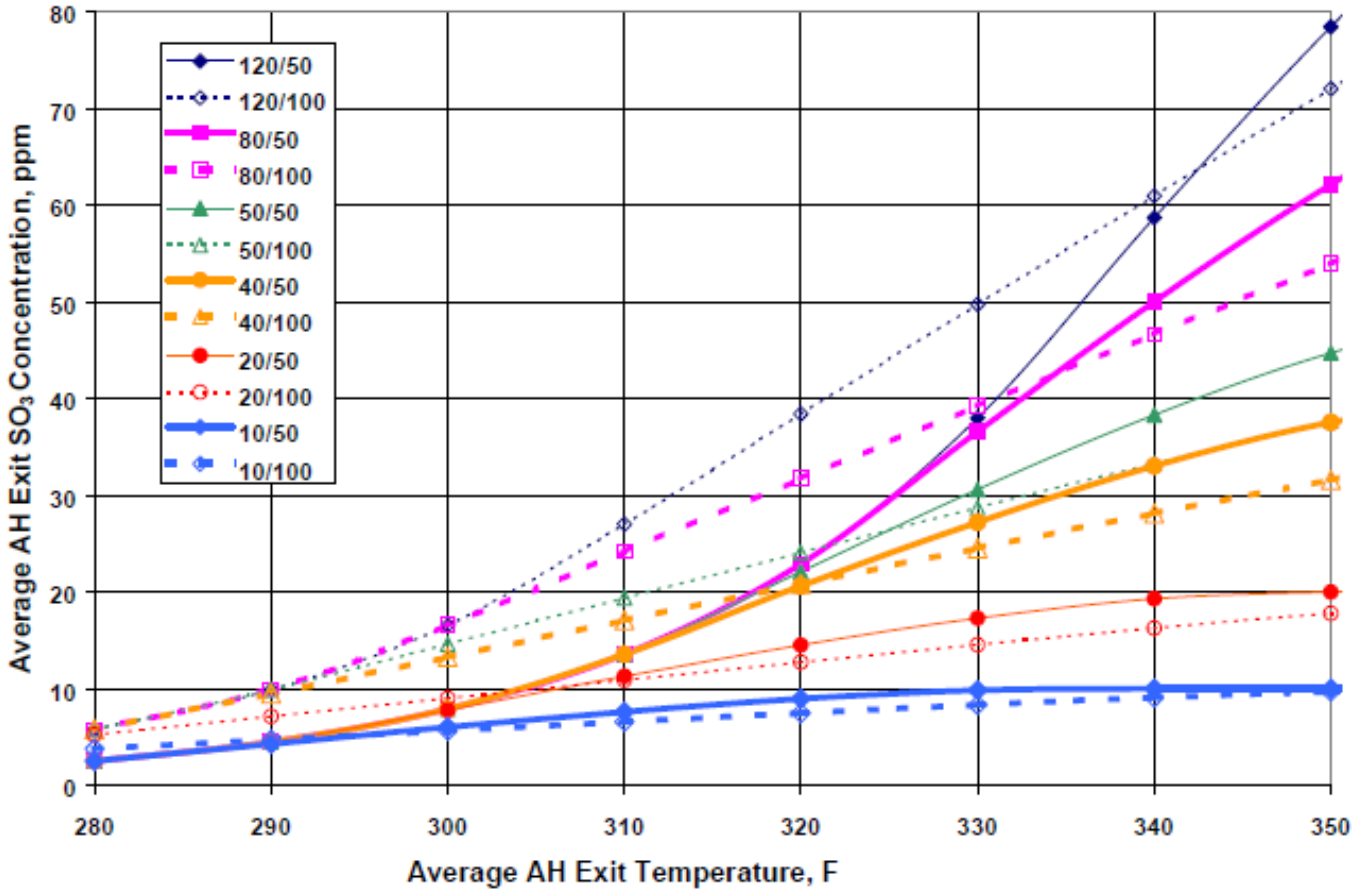


AbSensor – AbS/SO3 System

Breen Condensables System

- **Formation Temp**: **The temperature at which material will first form**
- **The Equilibrium Dew Point**
- **Evaporation Temp**: **The temperature at which material will self-evaporate**

SO_3 EXIT CONCENTRATION



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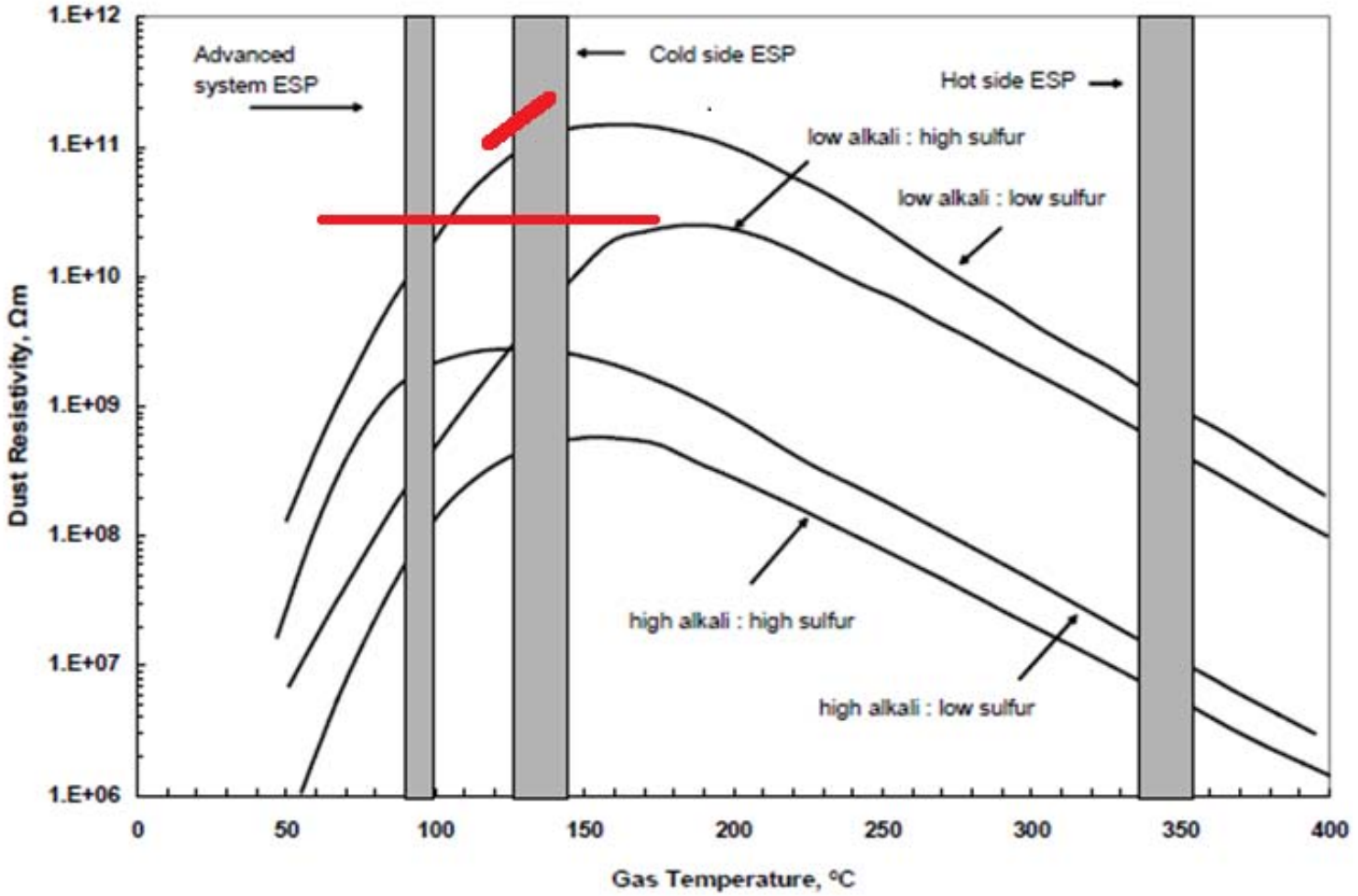
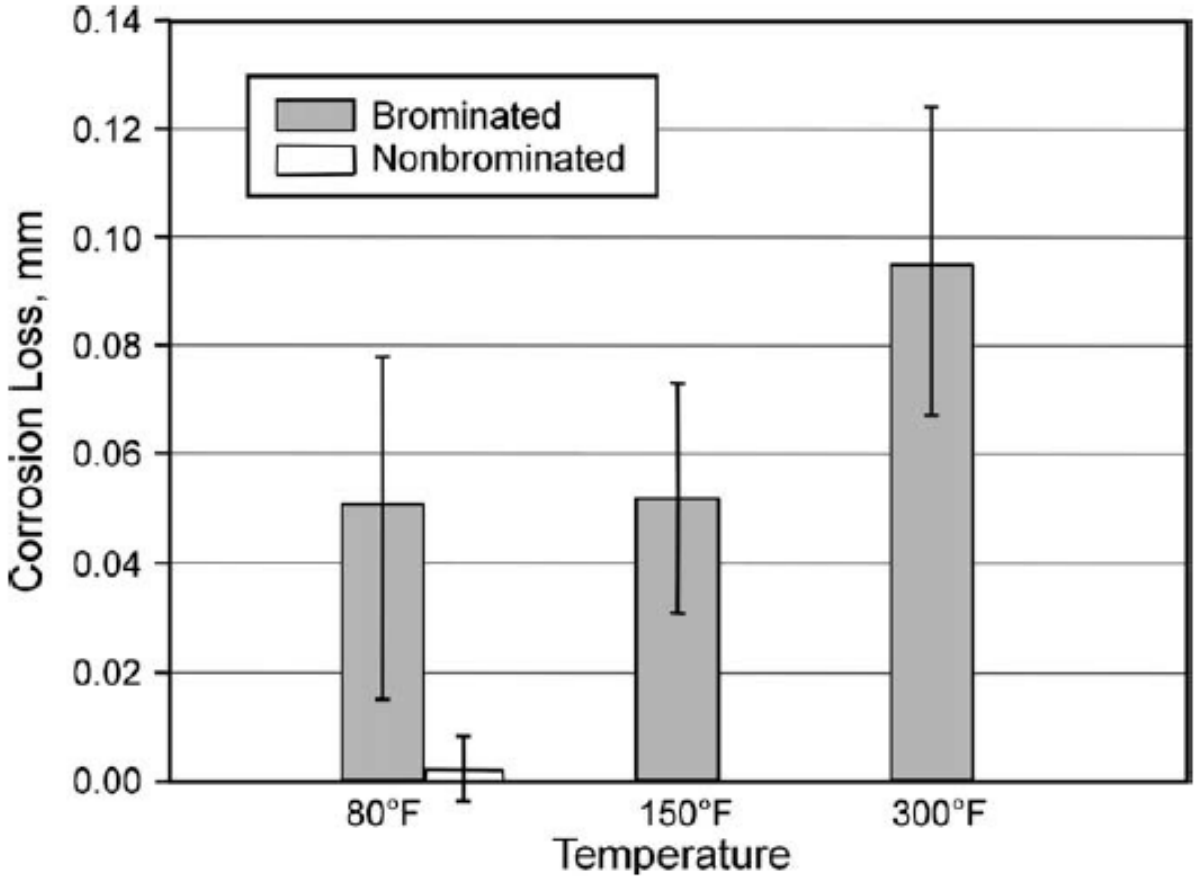
Fly Ash Resistivity

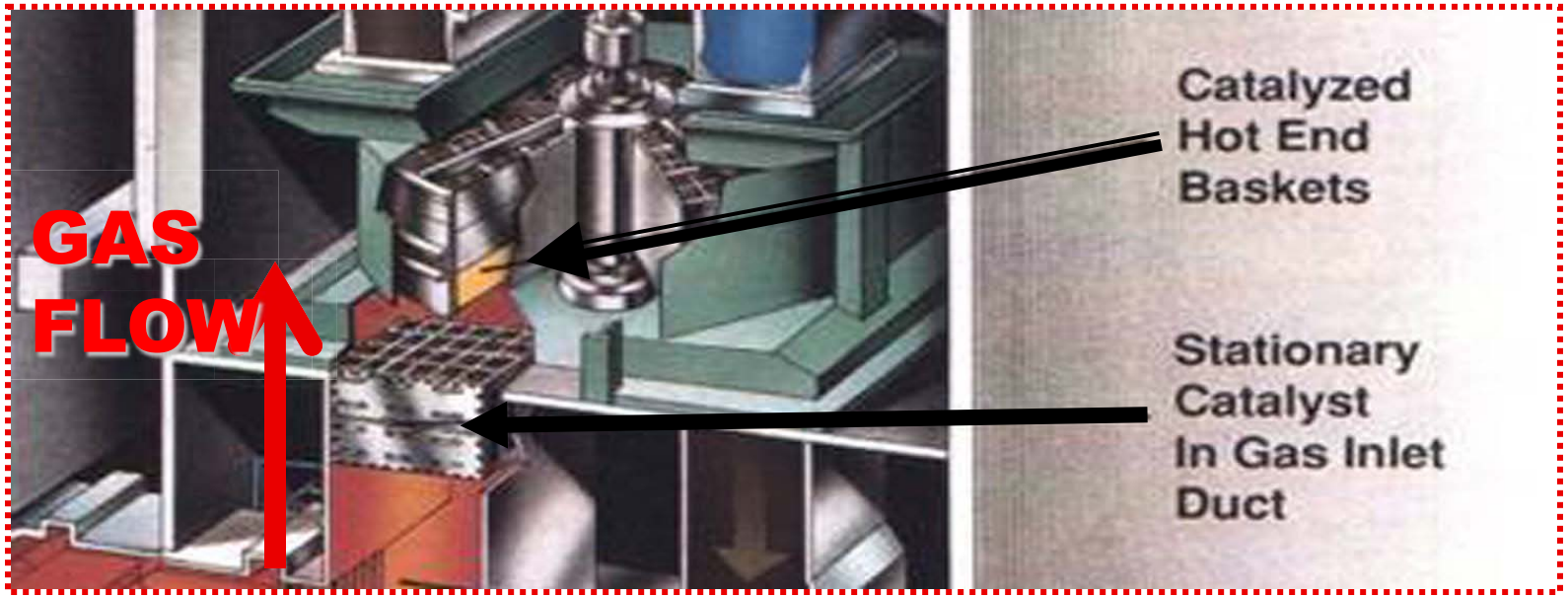


Br_2 GAS PHASE OXIDATION



EERC

Catalyst in Airheaters



AIR HEATER CAYALYST